EUVL – getting ready for volume introduction

SEMICON West 2010

Hans Meiling, July 14, 2010

Outline

- ASML's Lithography roadmap to support Moore's Law
- Progress on 0.25NA EUV systems
- Progress on 0.32NA EUV systems
- Outlook

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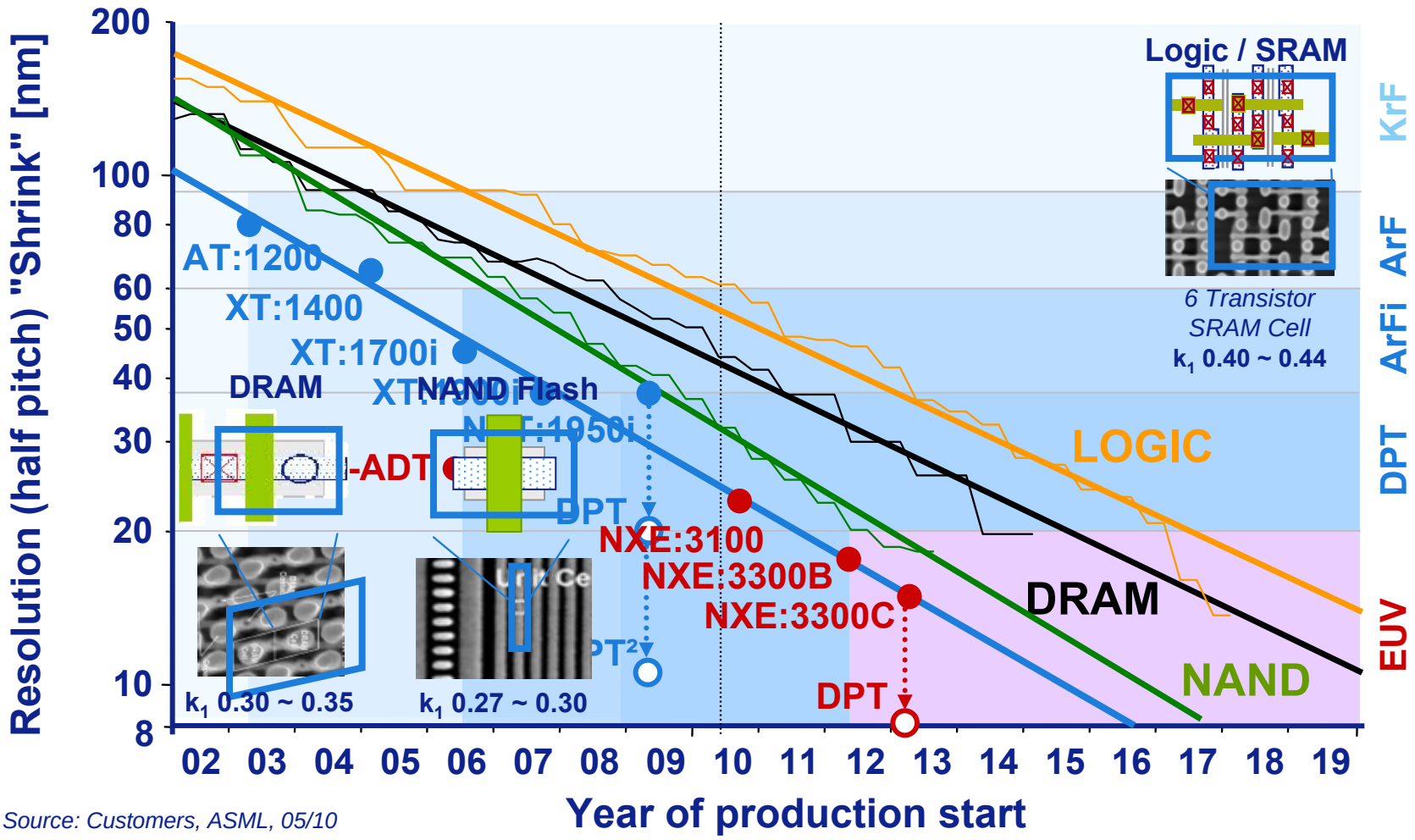
IC & Lithography roadmap towards <10nm



Source: Customers, ASML, 05/10

Notes:
1. R&D solution required 1.5~ 2 yrs ahead of Production
2. EUV resolution requires 7nm diffusion length resist
3. DPT = Double Patterning

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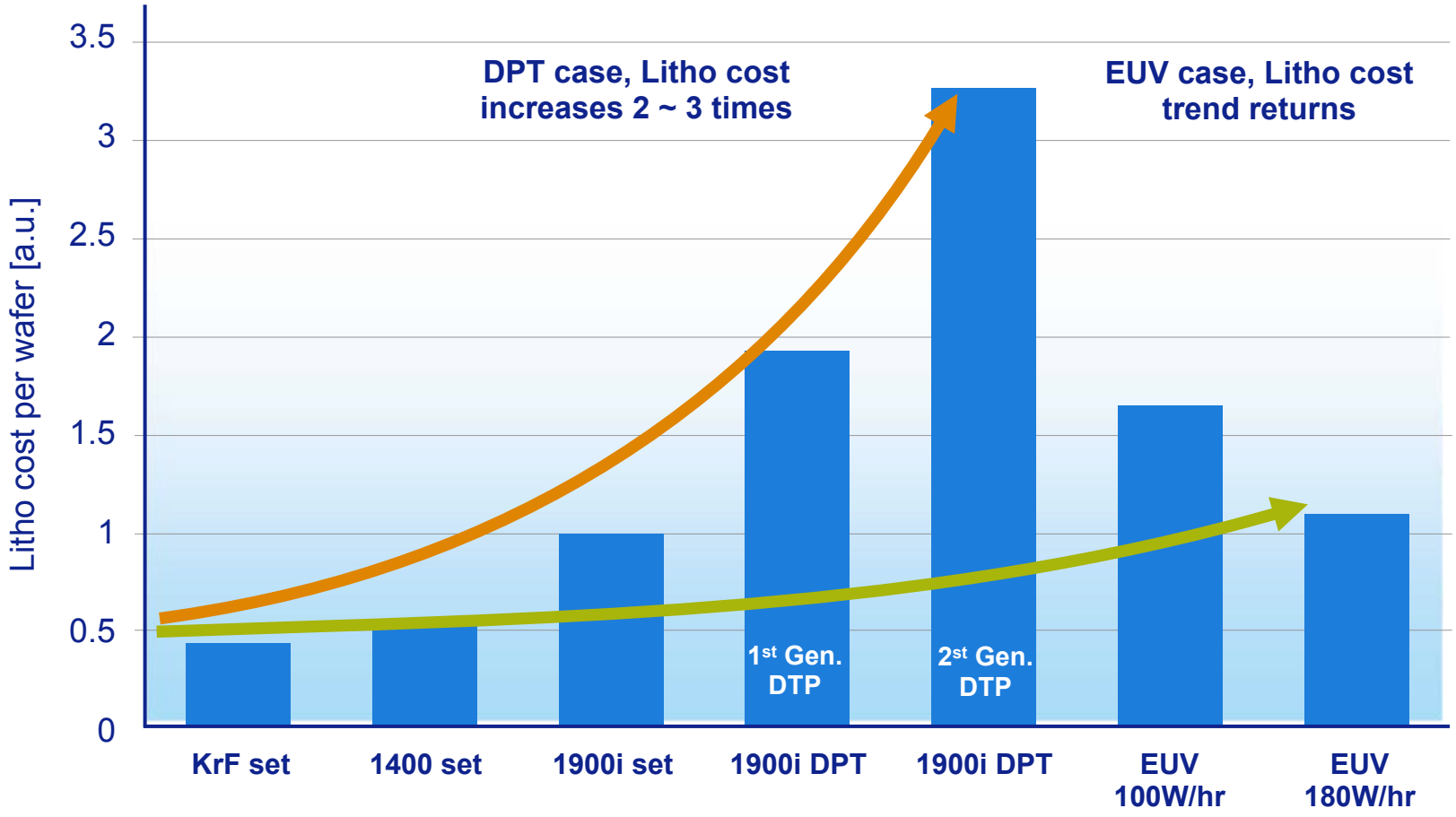
Litho costs back to normal with EUV >100 W/hr



Source: Samsung, Prague, oct 2009

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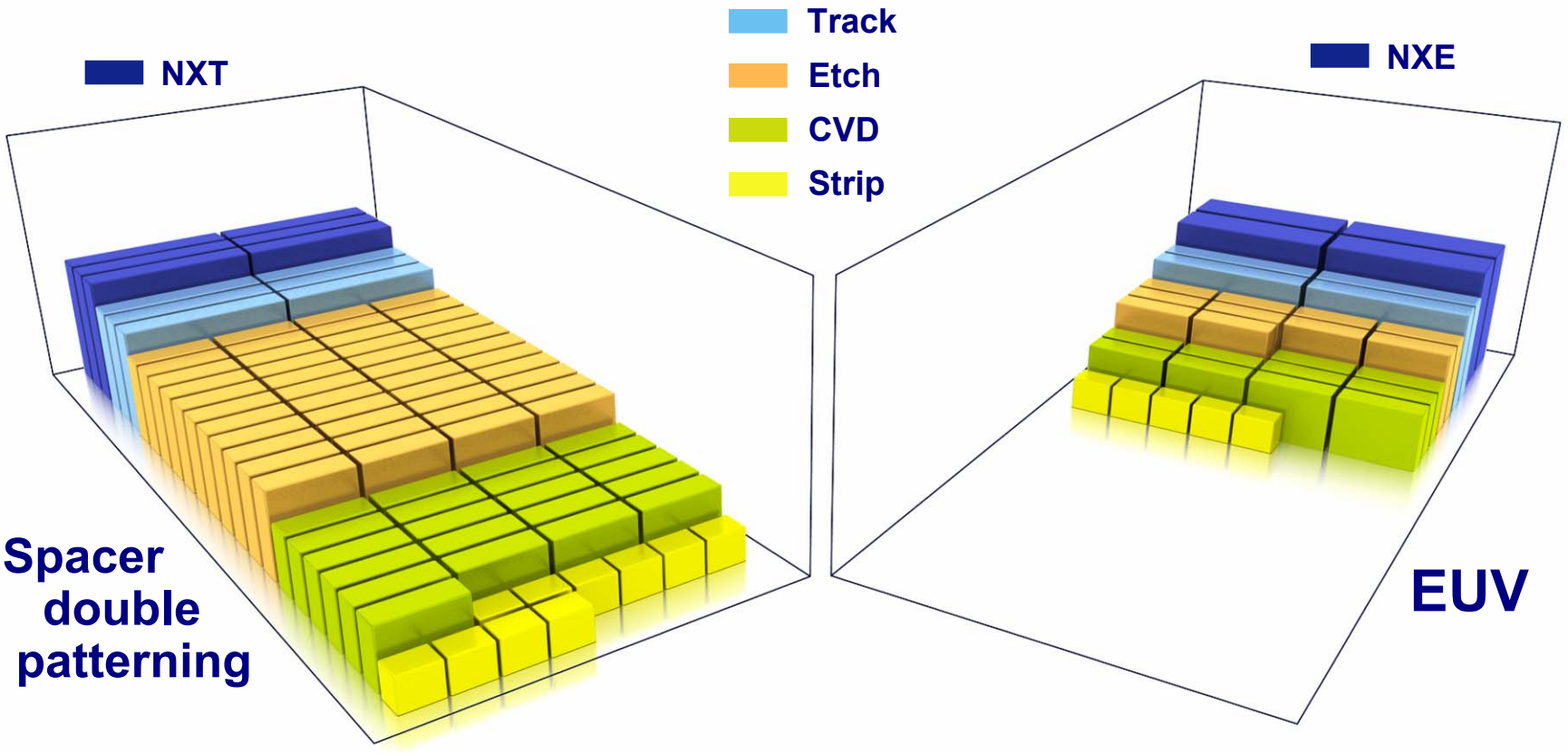
EUV can increase the fab capacity 2x

Larger footprint required to support Multi Patterning schemes



1200 m^2 clean room
130k Wafers / Month

627 m^2 clean room OR
250k Wafers / Month

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Critical issues EUV 2005-2009

2005 / 32hp	2006 / 32hp	2007 / 22hp	2008 / 22hp	2009 / 22hp
1. Resist resolution, sensitivity & LER met simultaneously	1. Reliable high power source & collector module	1. Reliable high power source & collector module	1. Long-term source operation with 100 W at IF and 5MJ/day	1. MASK
2. Collector lifetime	2. Resist resolution, sensitivity & LER met simultaneously	2. Resist resolution, sensitivity & LER met simultaneously	2. Defect free masks through lifecycle & inspection/review infrastructure	2. SOURCE
3. Availability of defect free mask	3. Availability of defect free mask	3. Availability of defect free mask	3. Resist resolution, sensitivity & LER met simultaneously	3. RESIST
4. Source power	4. Reticle protection during storage, handling and use	4. Reticle protection during storage, handling and use	• Reticle protection during storage, handling and use	• EUVL manufacturing integration
▪ Reticle protection during storage, handling and use	5. Projection and illuminator optics quality & lifetime	5. Projection and illuminator optics quality & lifetime	• Projection / illuminator optics and mask lifetime	
▪ Projection and illuminator optics quality & lifetime				

Source: Int'l SEMATECH, EUVL Symposium, Prague (Czech Republic), 2009

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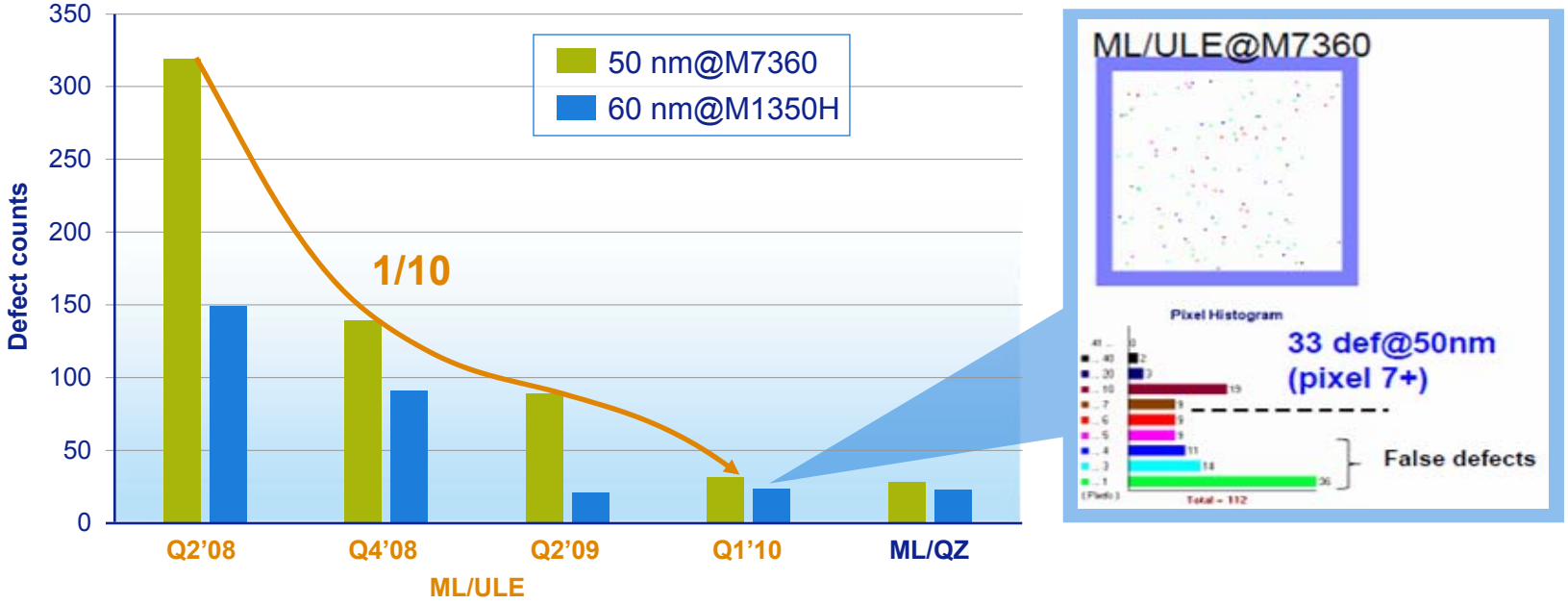
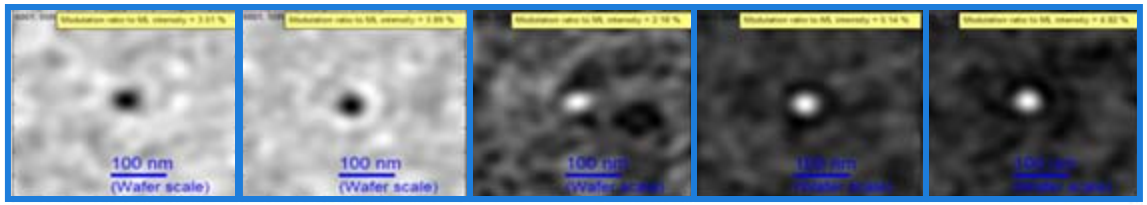
Mask infrastructure improvements on blanks & inspection near levels needed for pilot production



Optical inspection able to detect phase defects <3.4 nm x 45.4 nm in size[2]



1 Source: Hoya, Samsung EUV conference april 2010
2 Source: KLA, EUV symposium Prague, October 2009

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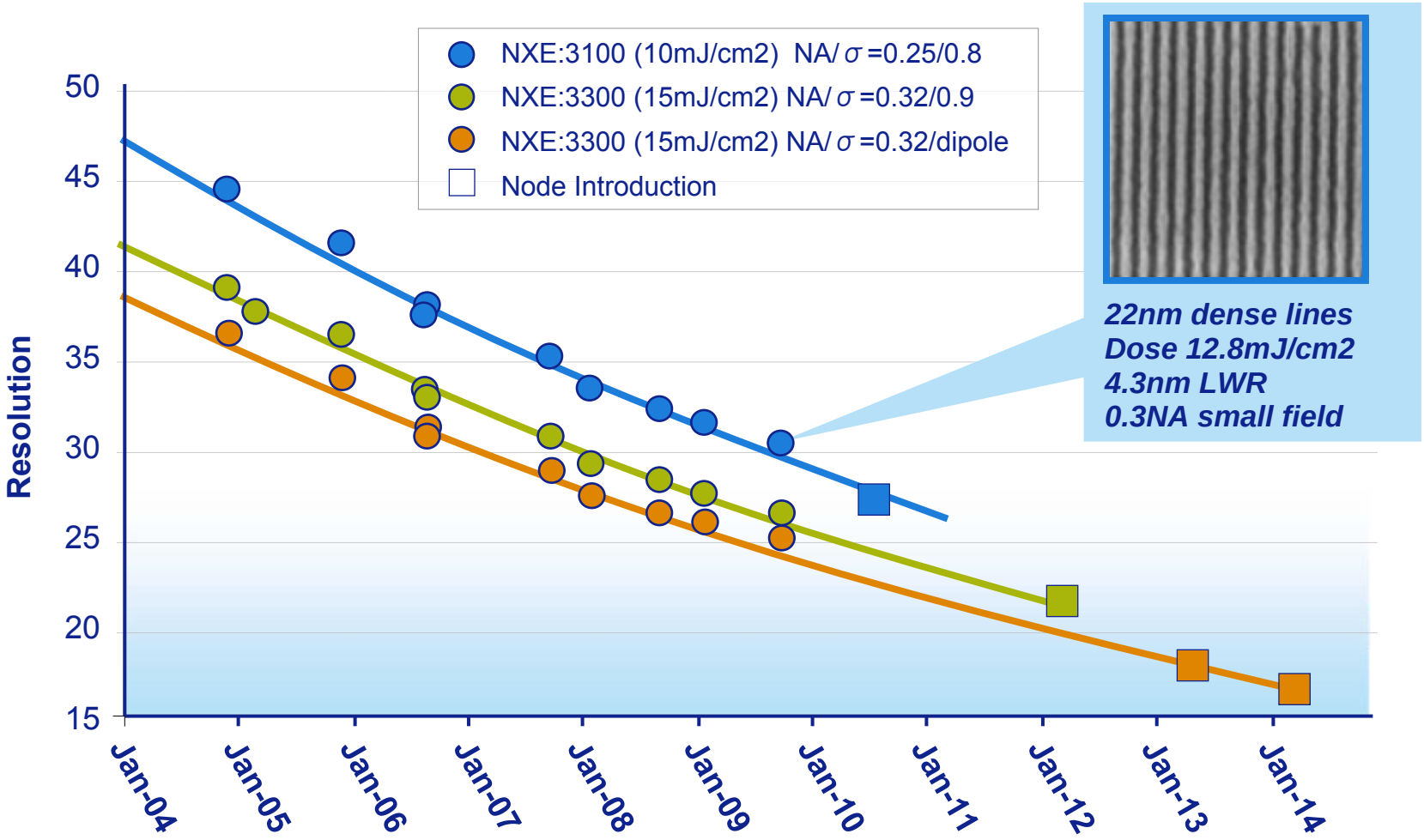
EUV resist makes steady progress

Extrapolation of 2004-2010 progress matches shrink roadmap



Source: 22nm, Younkin et. al, Intel, 0.3NA MET tool, EUVS Prague, 2009
data scaled to resolution, dose, LWR, optics contrast
and 7% LER by KLUP/z-factor scaling

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EUVL Roadmap supports many generations of shrink

	2006 Proto System	2010 NXE:3100	2012 NXE:3300B	2013 NXE:3300C
Resolution	32 nm	27 nm	22 nm	16* nm
NA / σ	0.25 / 0.5	0.25 / 0.8	0.32 / 0.2-0.9	0.32 / OAI
Overlay (SMO)	< 7 nm	< 4.5 nm	< 3.5 nm	< 3 nm
Throughput W/hr	4 W/hr	60 W/hr	125 W/hr	150 W/hr
Dose, Source	5 mJ/cm^2, ~8 W	10 mJ/cm^2, >100 W	15 mJ/cm^2, >250 W	15 mJ/cm^2, >350 W

Main improvements
1) New EUV platform: NXE
2) Improved low flare optics
3) New high sigma illuminator
4) New high power source
5) Dual stages

Main improvements
1) New high NA 6 mirror lens
2) New high efficiency illuminator
3) Off-axis illumination optional
4) Source power increase
5) Reduced footprint

Platform enhancements
1) Off-Axis illumination
2) Source power increase

* Requires <7 nm resist diffusion length

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EUV process viability confirmed by two 0.25NA Systems

Source: IMEC (Leuven, Belgium)

λ	13.5 nm
NA	0.25
Field size	26 x 33 mm^2
Magnification	4x reduction
σ	0.5

- 300mm Single stage
- linked to track
- Single reticle load
- Uses TWINSCAN technology
- Sn discharge source

Source: University of Albany (Albany, NY) USA

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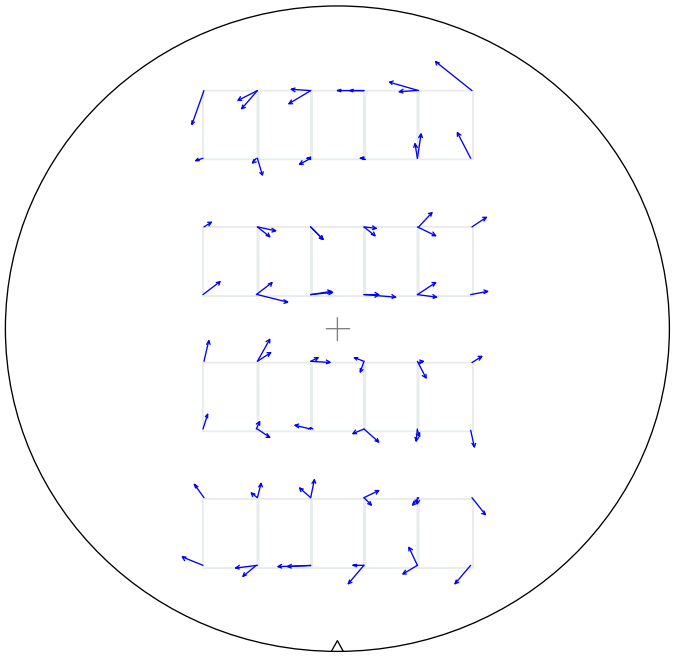
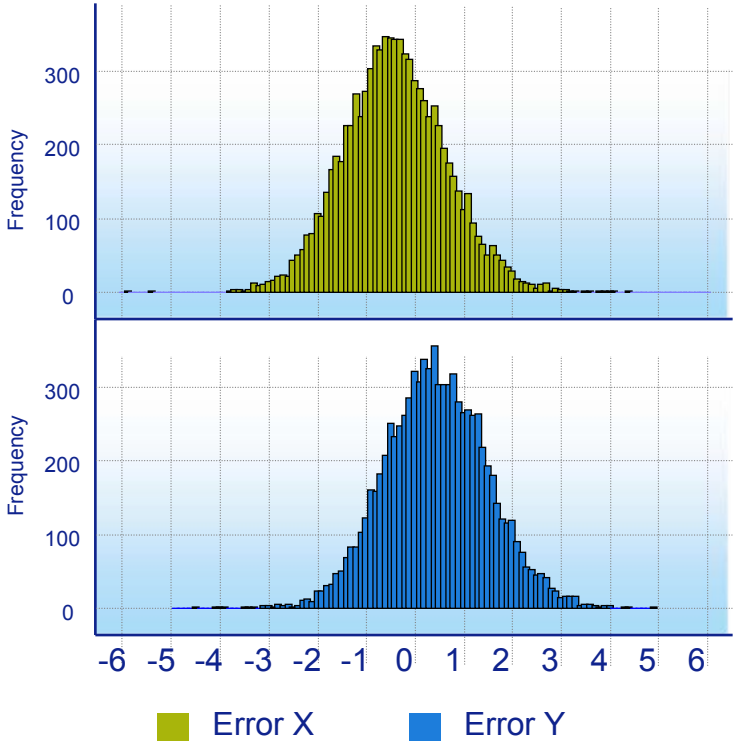
Overlay performance supports device integration

On-product Overlay Residuals
X = 8.0 nm, Y = 7.8 nm



Single Machine Overlay
X = 2.2 nm, Y = 2.8 nm



Source: GlobalFoundries, SPIE 2010

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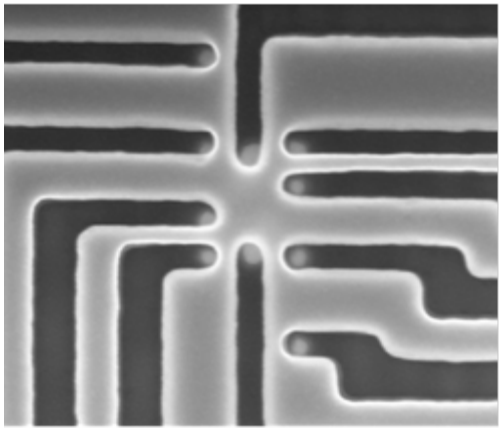
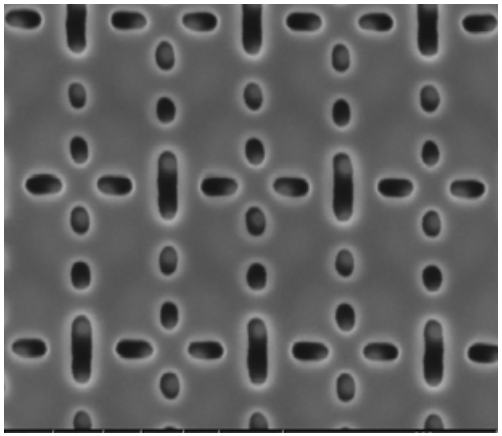
22 nm (0.079μm²) node SRAM after etch process integration

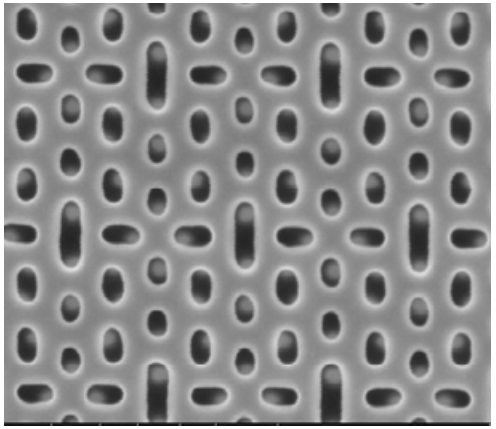
SRAM cell



Node [nm]	Half Pitch [nm]	Cell size [μm²]	Cell size shrink
45	80	0.314	
45	70	0.274	13%
32	62	0.186	32%
22	**52**	**0.079**	**58%**
16	35	0.042	47%

SRAM array





Source: IMEC, EUV Symposium '09 (Prague)

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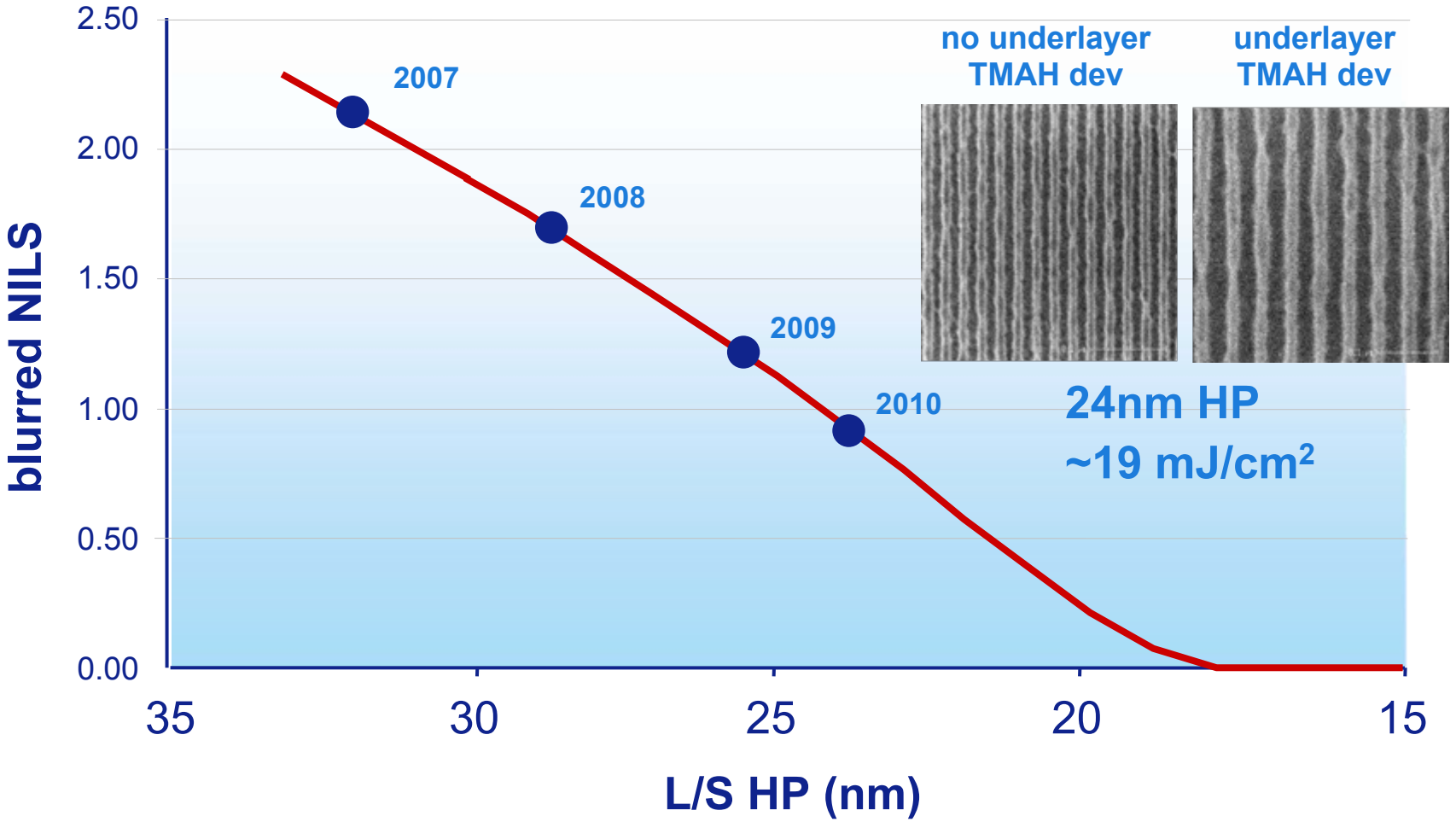
24nm champion resolution on 0.25NA/0.5σ system

From ~32nm half-pitch in 2007 to 24nm in 2010



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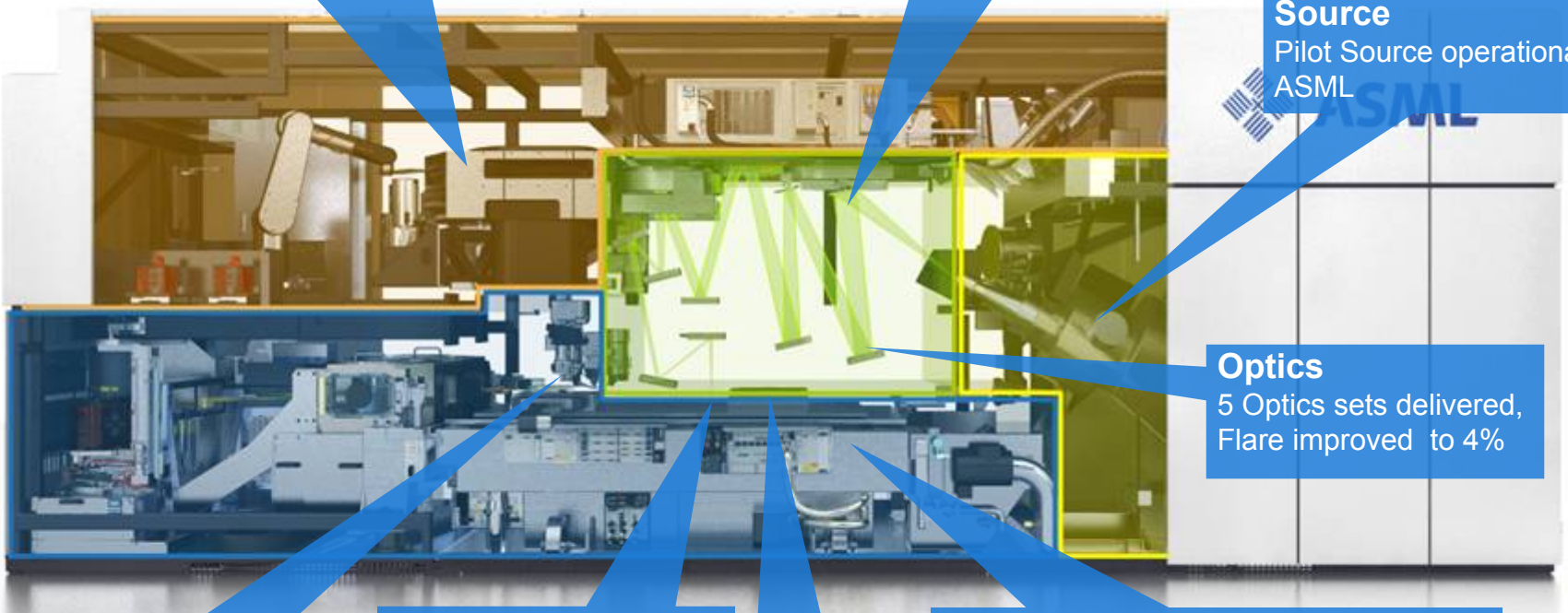
NXE:3100 integration status, July 2010

Reticle Stage and Handler
Reticle Handling and Stage control in vacuum
Reliability testing since Q4/2009

Vacuum
system design verified,
<1hour pump down

Source
Pilot Source operational at ASML



Optics
5 Optics sets delivered,
Flare improved to 4%

Metrology
Alignment and Leveling demonstrated, Metrology position fully functional

Overlay
Ongoing

Imaging
First slit exposed

Wafer Stage and handler
Wafer handling and scanning in vacuum
Reliability testing since Q4/2009

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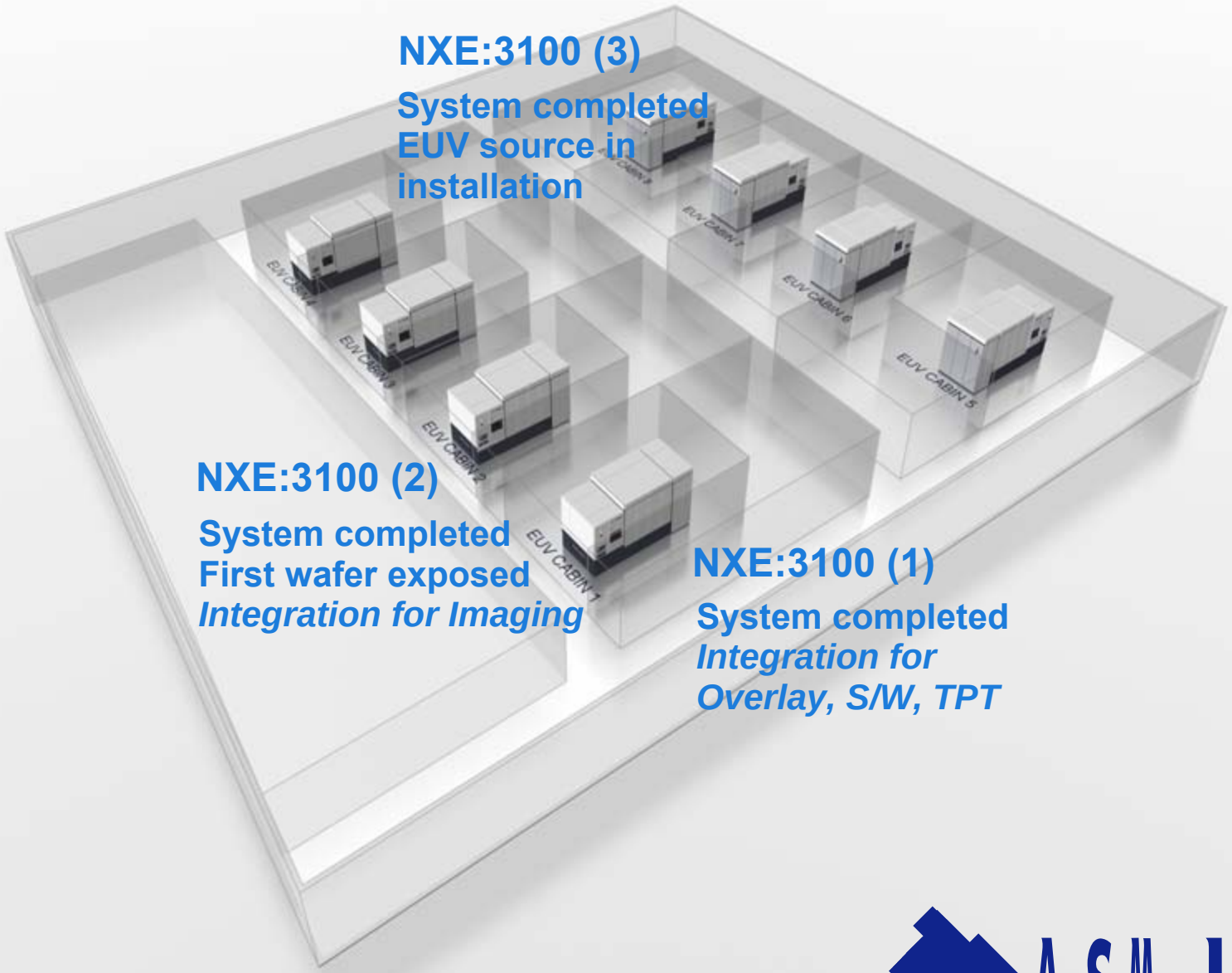
NXE:3100 integration: 3 systems completed



NXE:3100 (3)

System completed
EUV source in installation

NXE:3100 (2)

System completed
First wafer exposed
Integration for Imaging

NXE:3100 (1)

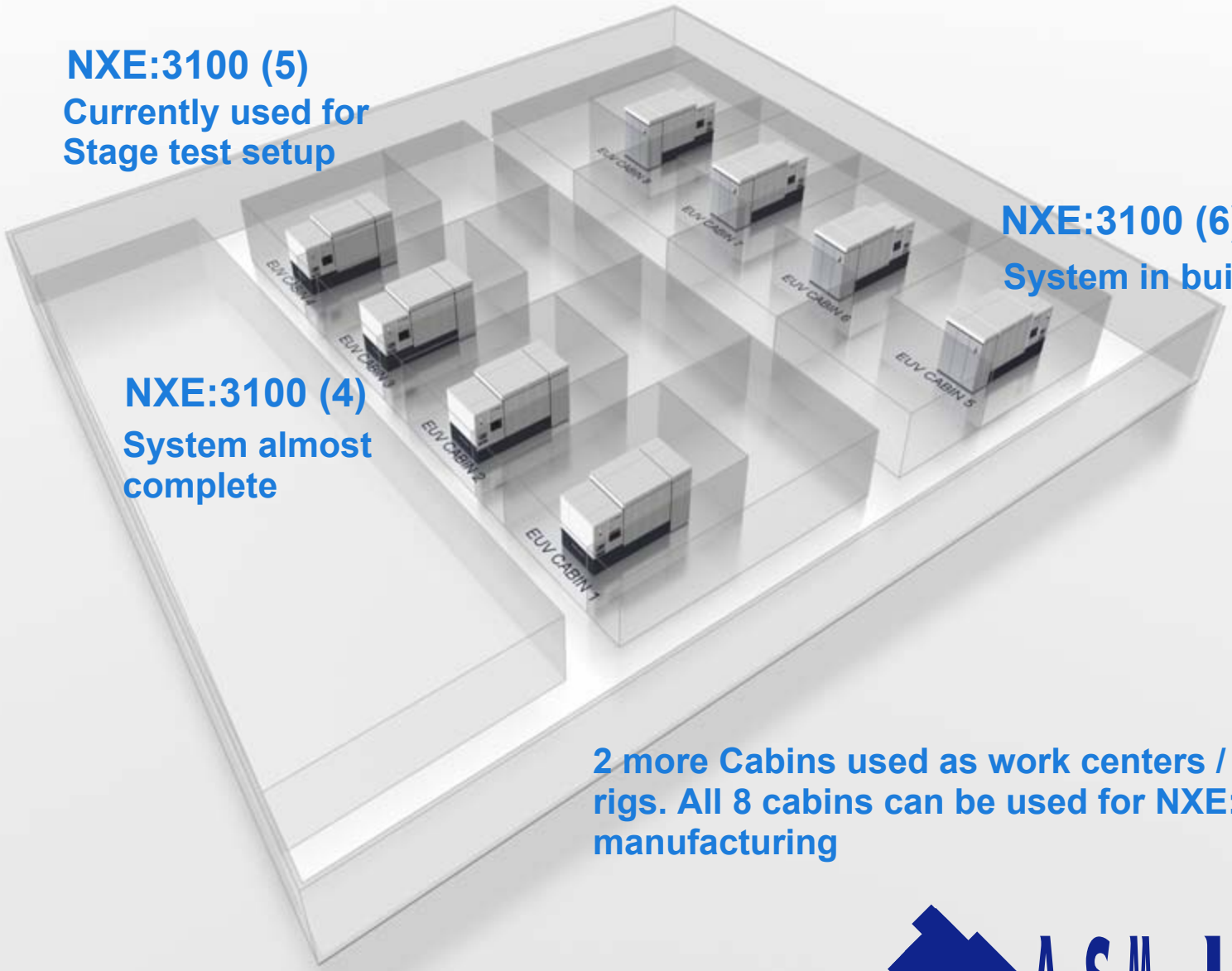
System completed
Integration for Overlay, S/W, TPT

3 more NXE:3100 systems in build-up

NXE:3100 (5)
Currently used for
Stage test setup

NXE:3100 (6)
System in buildup

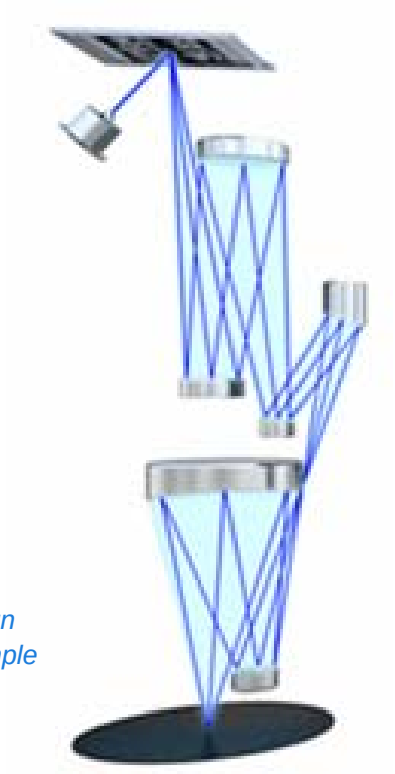
NXE:3100 (4)
System almost
complete



2 more Cabins used as work centers / test rigs. All 8 cabins can be used for NXE:3300 manufacturing

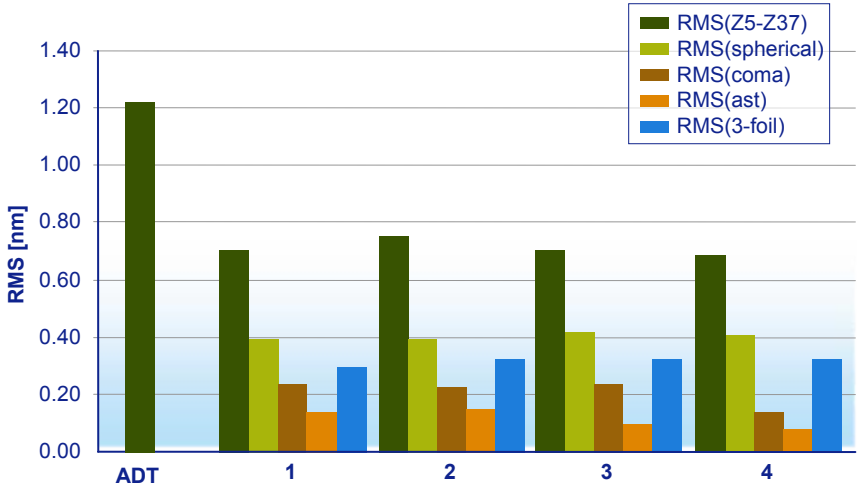
Multiple 3100 lenses manufactured and qualified

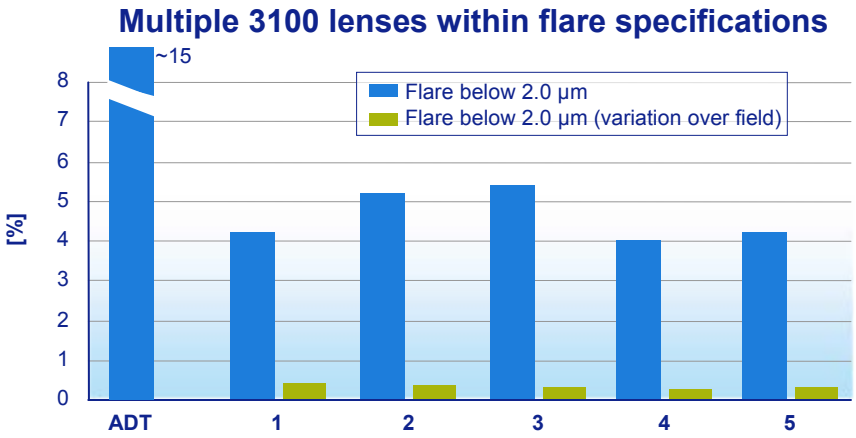
Wavefront qualified by EUVL interferometer



design example

- Field size: 26mm
- Chief ray at mask: 6°
- 4x reduction ring field design
- Design is extendable to higher NA





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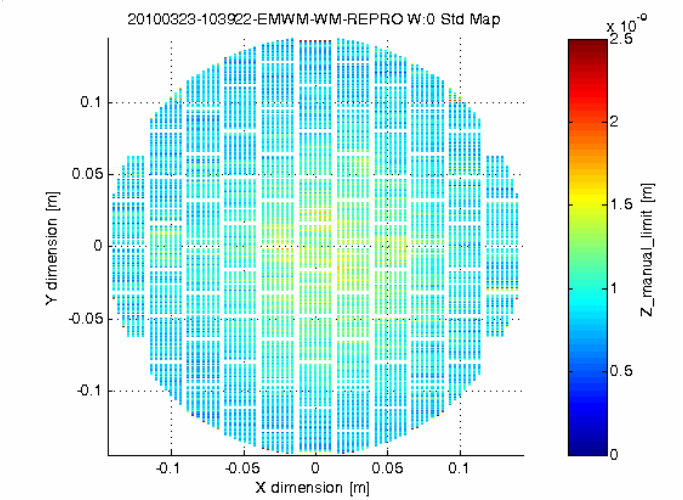
NXE metrology verified in vacuum

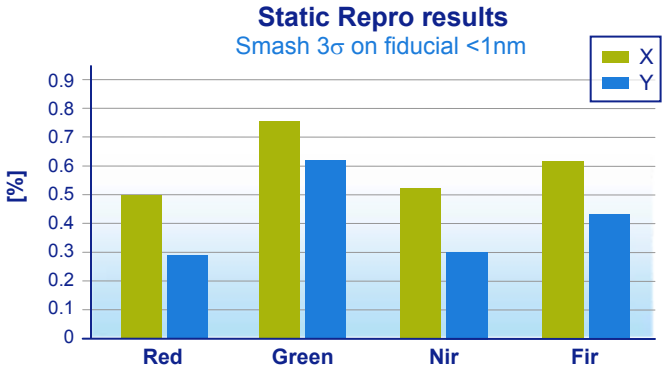
Focus and Levelling

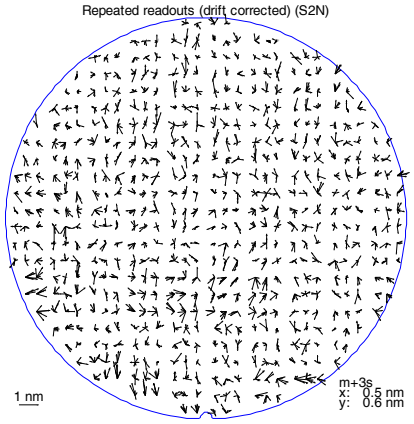


Mean standard deviation over wafer: 0.9 nm

99.7% value of standard deviations: 1.6 nm

Alignment





Multiple wafer readout 3σ = 0.6 nm

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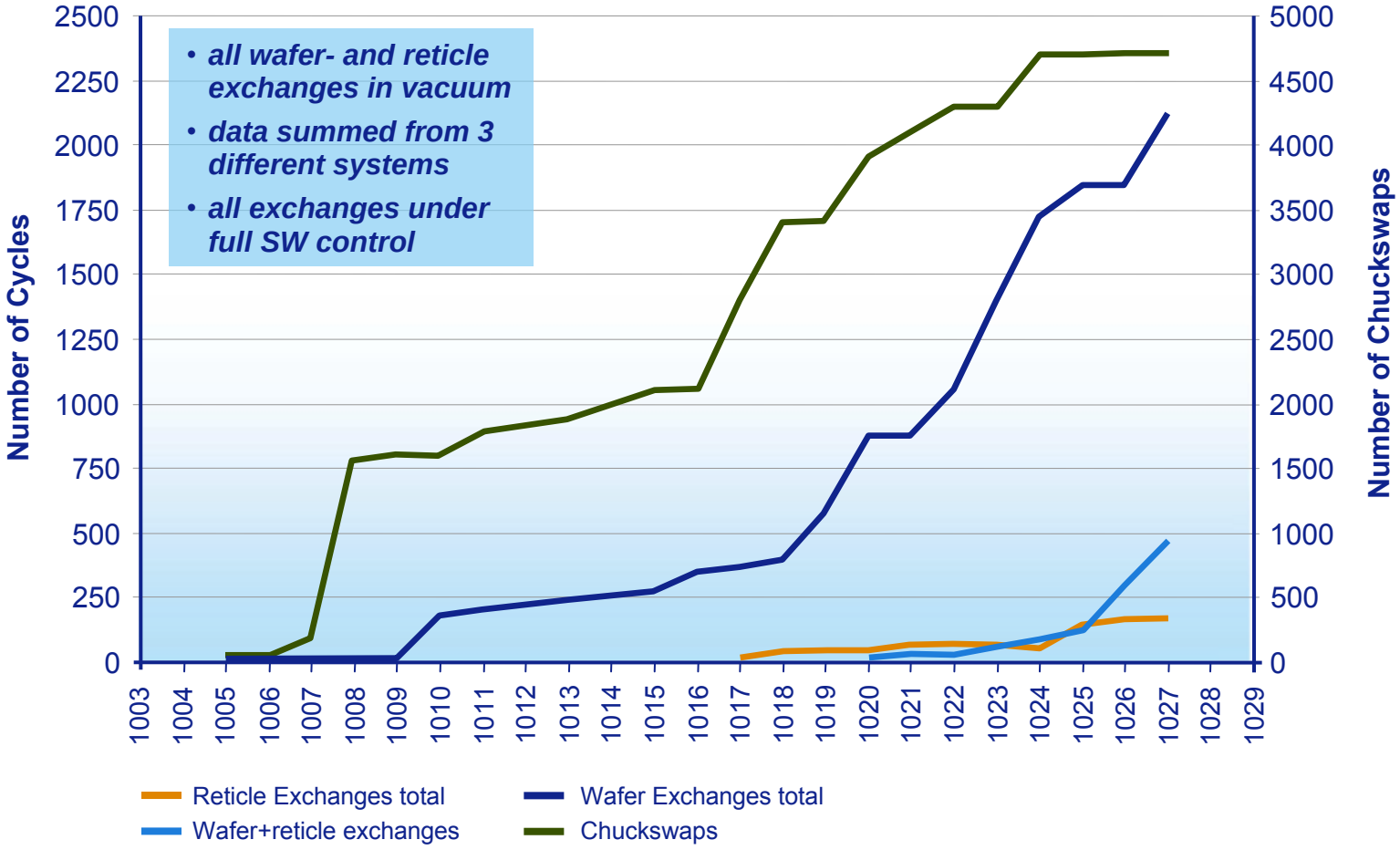
Reliability testing ongoing on multiple systems

Focus on wafer- and reticle exchange functionality



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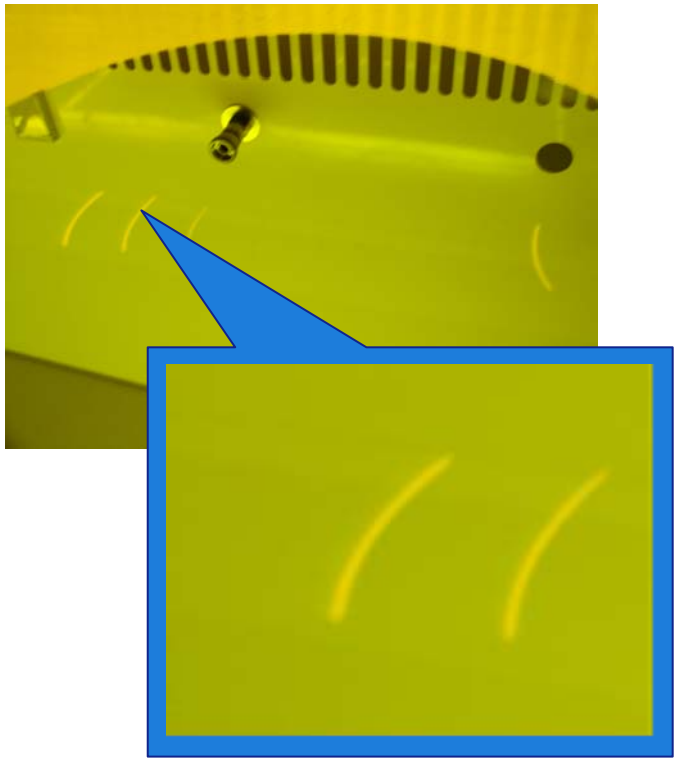
Sources integrated with systems at ASML

First EUV exposures made

Source vessel operational and integrated with scanner system

CO_2 laser operational and integrated with scanner system

First EUV wafer exposed on integrated system



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On-site source performance: current and expectation

Performance as installed at ASML

- Two sources shipped to ASML, 3rd one in acceptance testing.
- Two power upgrades* are planned
  - Upgrade #1
    - Increased CO_2 power by increased laser gain length.
  - Upgrade #2
    - Increased CO_2-to-EUV conversion efficiency.

Source Configuration	Raw Power	Expose Power
Baseline	40 W	20 W
Upgrade #1	80 W	40 W
Upgrade #2	200 W	100 W

- Stable collector performance achieved on proto source.

*Ref.: D.C. Brandt (Cymer), SPIE 2010.

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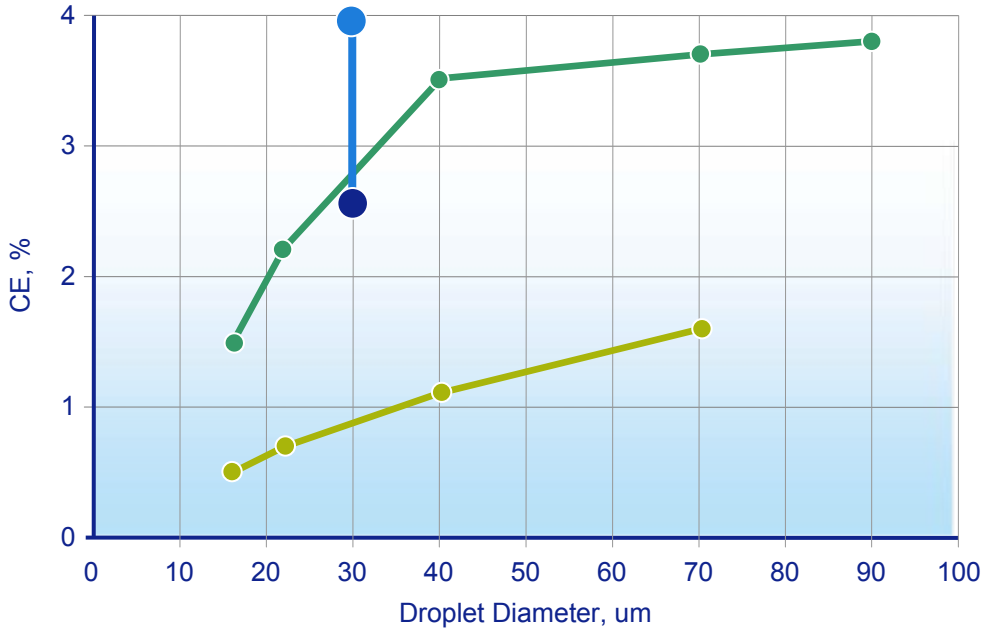
Upgrade #2: Pre-pulse proof-of-concept being validated



With Pre-Pulse
Without Pre-Pulse

pulse-peak CE, measured 2Q'10
pulse-average CE, measured 2Q'10

- The target size and density can be optimized by striking the droplet with a pre-pulse laser.
- The energy of the pre-pulse laser is much less than the main pulse and acts to expand the droplet size and reduce its density.
- Both the energy and timing of the pre-pulse can be adjusted to achieve best performance.

Ref.: D.C. Brandt (Cymer), SPIE 2010.

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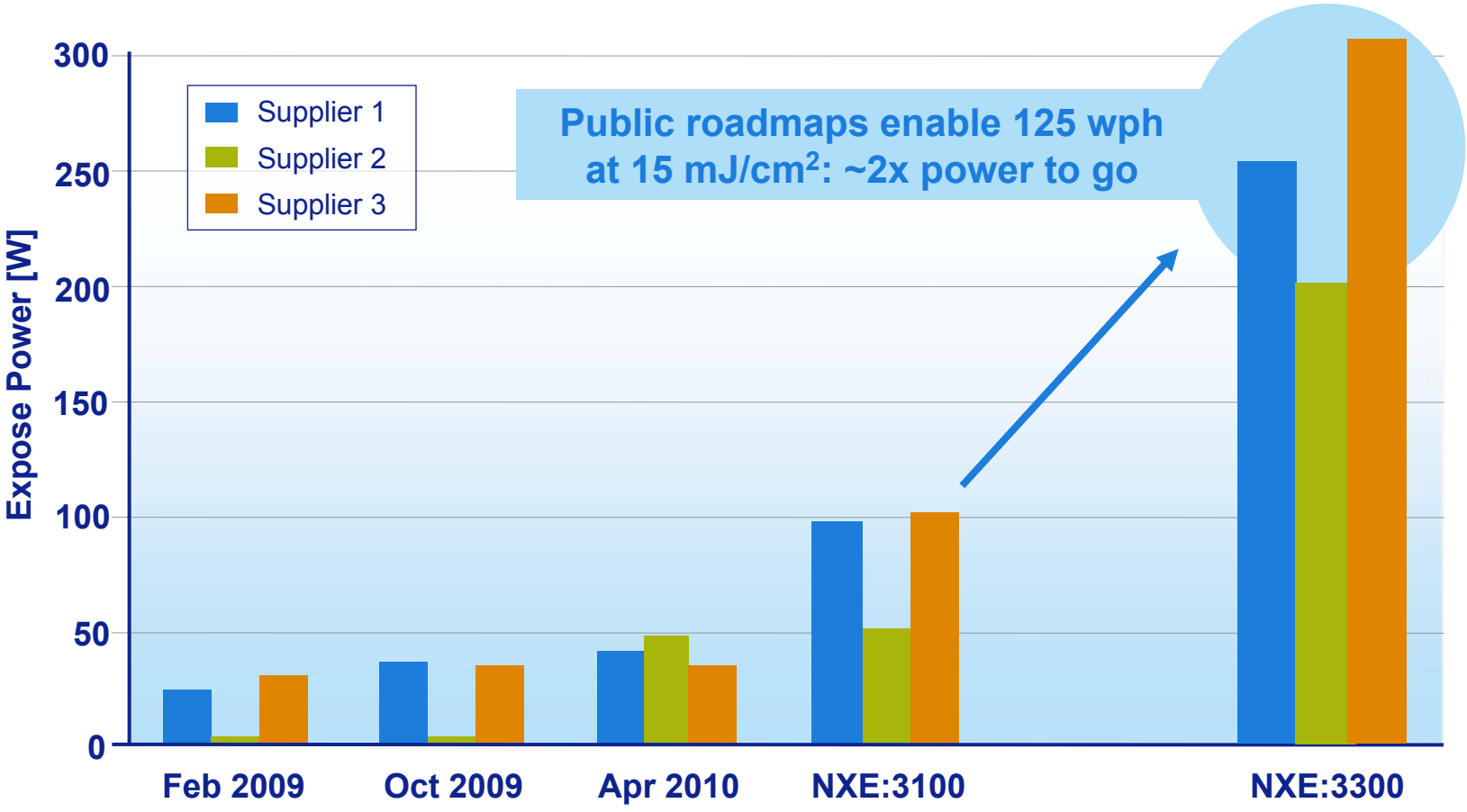
Significant source progress required for NXE 3300

Roadmap commitments from multiple suppliers enable NXE productivity



Source: Cymer, Ushio, Gigaphoton, SPIE 10, Gigaphoton Press release April 2010
published data scaled with dose control and spectral filtering losses
Data April 2010: Cymer – 30um droplets, Gigaphoton 60um droplets

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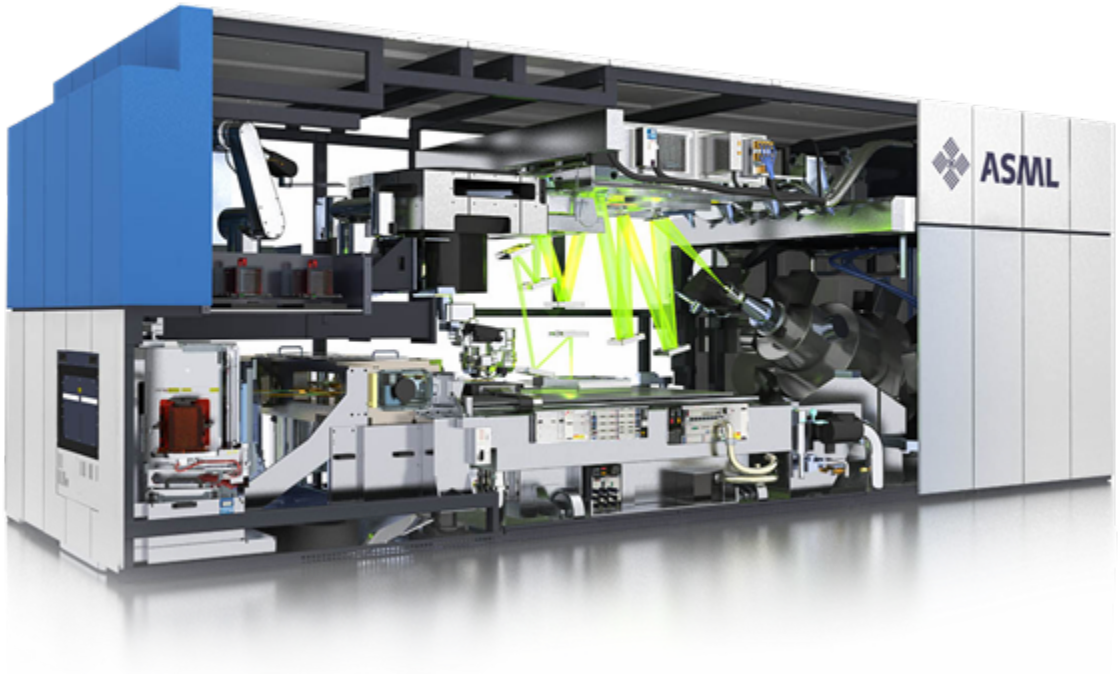
NXE:3300B 1st shipment: H1 2012

2nd generation of NXE platform



Specifications

- NA = 0.32
- Resolution 22 nm; 18/16nm with OAI
- Overlay 3.5 nm
- Productivity 125 wph 15 mJ/cm^2 resist

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Six-mirror lens design is extendable to 0.32 NA

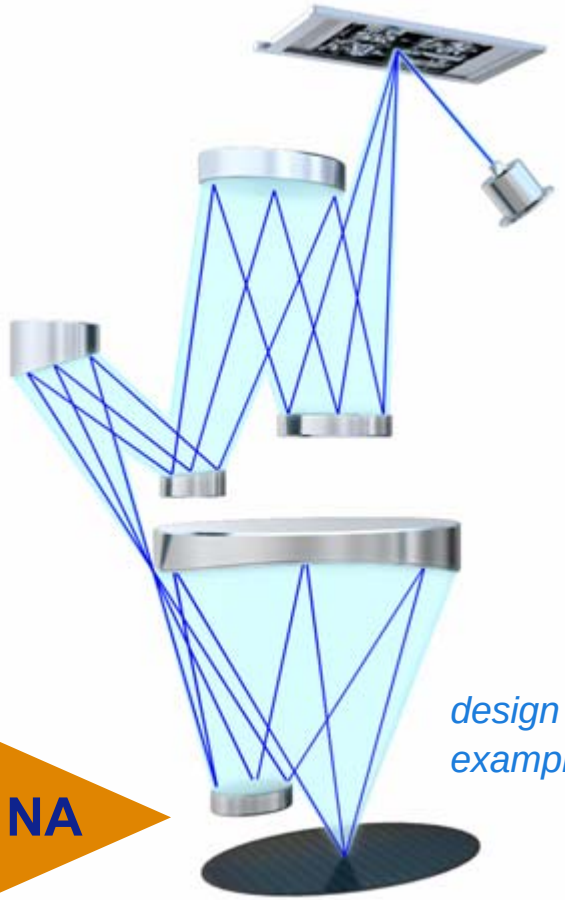
Resolution improves from 27 to 22 nm

NXE:3100

- Field size 26 mm
- Chief ray at mask 6°

- Design complexity/cost increases
  - Larger mirrors
  - Steeper aspheric mirrors
  - High angles of incidence

0.25 NA → **0.32 NA**



design examples

NXE:3300

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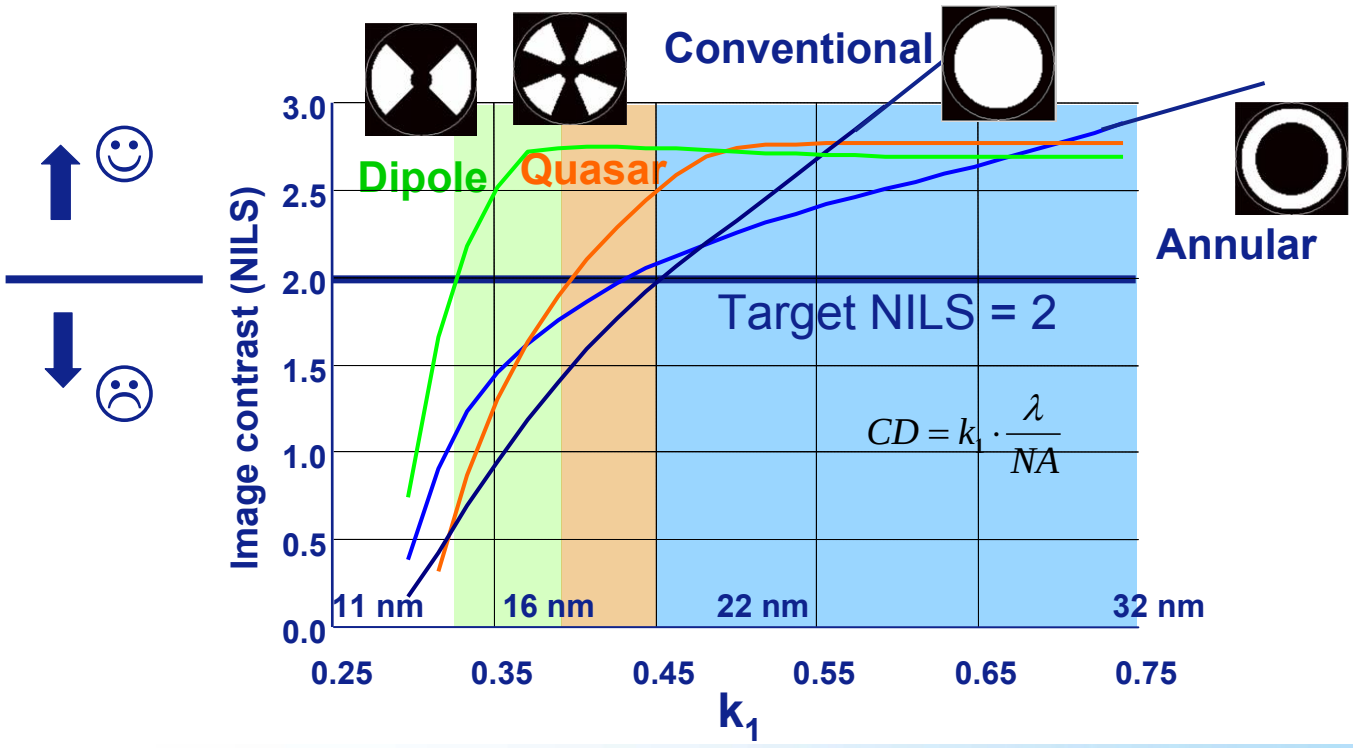
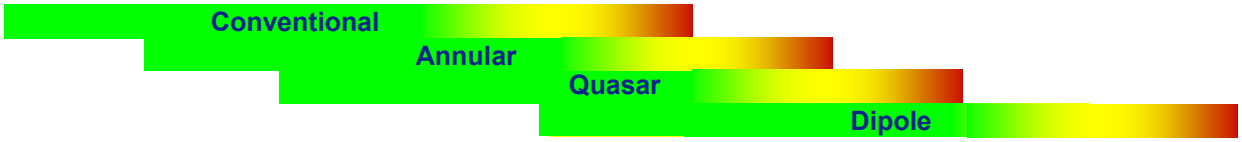
Further resolution improvement with off-axis illumination

With dipole illumination resolution improves to below 16 nm



half pitch	32 nm	28	24	22 nm	20	18	16 nm	13	11 nm
k1	0.76	0.66	0.57	0.52	0.47	0.43	0.38	0.31	0.26



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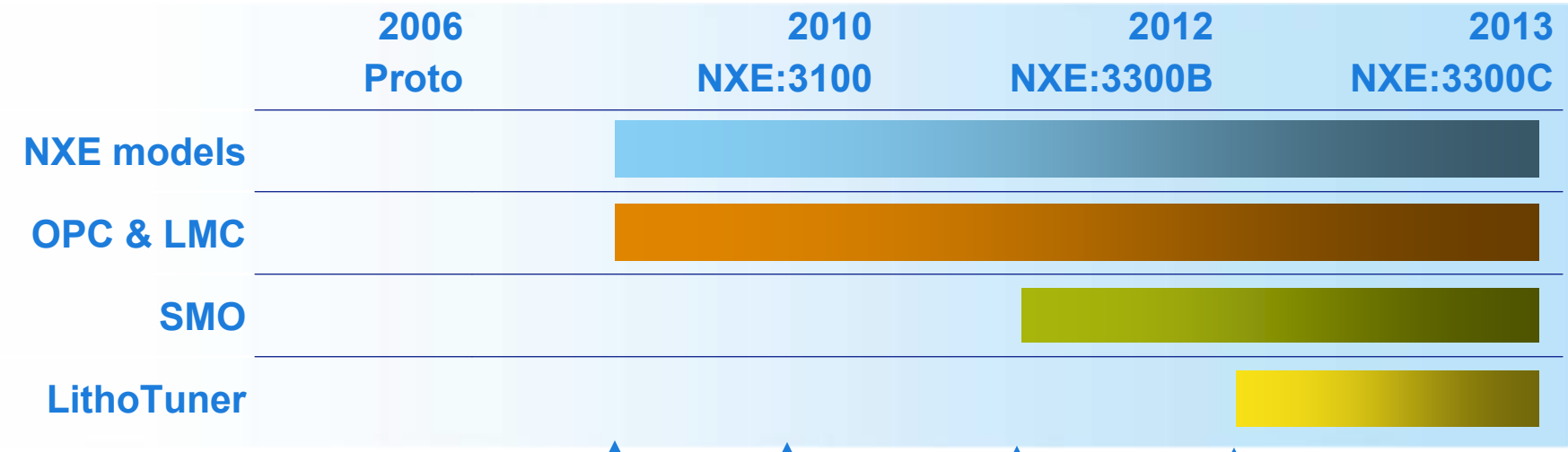
ASML c-lithography roadmap supports EUVL

Support of ASML EUV scanners through Brion products



2009.09 release
1. Beta release
2. Modeling, correction and verification for flare, mask shadowing and low k_1 proximity effect

2010.06 release
1. Production release
2. Models: NXE:3100
3. Optimized Process Correction (OPC)
4. OPC Verification (LMC)

2011.06 release
1. Models: NXE:3100, NXE:3300B
2. Source Mask Optimization (SMO)

2012.06 release
1. Models: NXE:3100, NXE:3300B, 3300C
2. LithoTuner

LMC = Lithography Manufacturability Check
SMO = source-mask optimization

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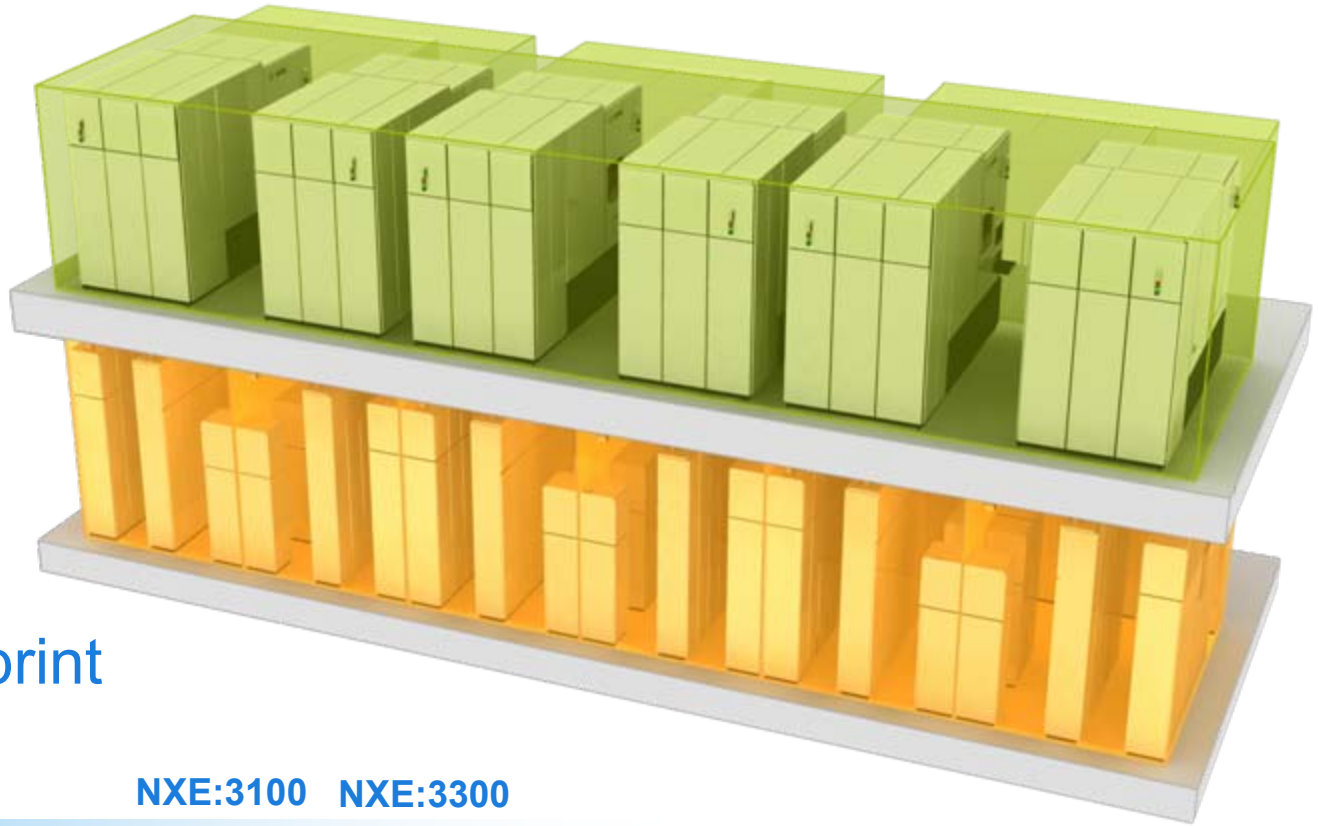
NXE:3300 footprint target is <50% of NXE:3100

Incl. shared service area, for multiple systems in fab.

Service Area
Sub fab Area



NXE:3300 Footprint

	NXE:3100	NXE:3300
Exposure Unit footprint:	**1**	**0.8**
Subfab footprint (excl. prepumps, abatement)	**1**	**0.4**
Total footprint (incl. service area)	**1**	**0.4**

(all area's normalized to 3100)

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NXE:3300 mirrors are in production at Zeiss

Construction of new EUV facilities has started

Planned NXE production capacity increases ~3x

Existing EUV offices & manufacturing, 8 cabins.

New EUV offices & manufacturing,15 cabins.

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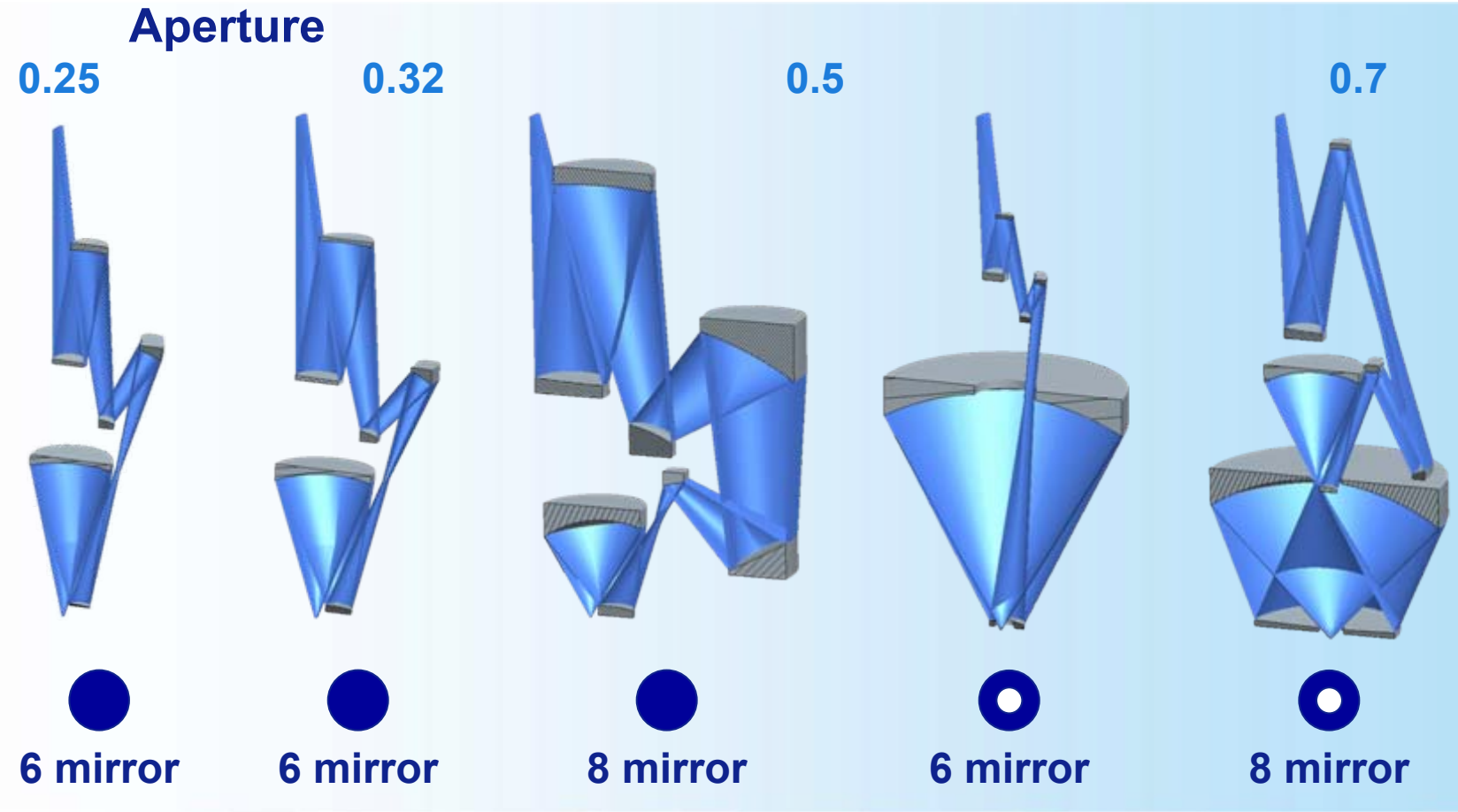
EUV extendibility possible beyond 10 nm resolution

Through increase of the aperture up to 0.7



Unobscured Central obscuration

design examples

Reference: W.Kaiser et al, SPIE 2008 6924-4

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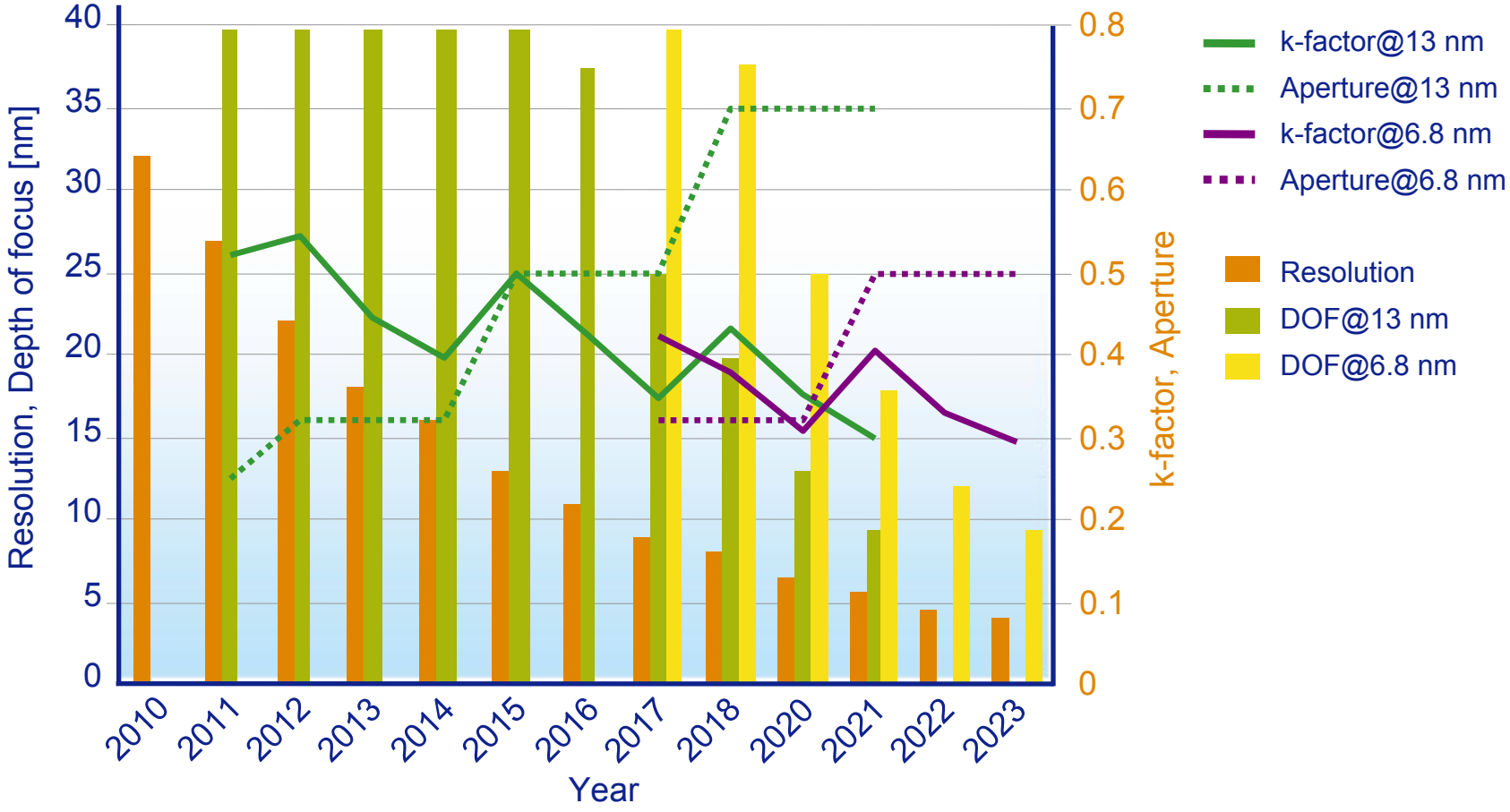
Extendibility of EUV down to sub 5 nm possible

Increasing apertures up to 0.7, wavelength reduction down to 6.8 nm
using 13 nm compatible optics with depth of focus as the major challenge



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Summary

- 6 NXE:3100 systems have been ordered by customers, in all market segments, worldwide.
  - 1st HVM source for NXE:3100 is operational at ASML.
    - performance supports system integration, and needs upgrades for 60 W/hr.
  - NXE:3100 in final integration phase for shipment H2 2010.
    - first wafer exposed, reliability testing ongoing.
- NXE:3300B with 0.32 NA optics is planned for 1H 2012.
  - 3 source suppliers committed to meet productivity target.
  - optics manufacturing has started.
- EUVL is extendible for multiple nodes through NA and wavelength changes.

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public